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A QUANTIFIABLE METHOD OF ASSESSING THE RISK OF SELECTING THE LOWEST BIDDER IN CONSTRUCTION PROJECTS: A LITERATURE REVIEW

G. Eke, G. Wedawatta and J. Elgy

School of Engineering and Applied Sciences, Aston University, Aston Express Way, Birmingham B4 7ET.

Email: ekegue@aston.ac.uk

Abstract: Contractor selection is an important step in ensuring the success of any construction project. Failing to adequately select the winning contractor may lead to problems in the project delivery phase such as bad quality and delay in the expected project duration; which ultimately results in cost overruns. This paper reviewed the strength of existing studies on the link between contractor selection strategy and project outcomes, with a view of proposing an approach on how one might try to examine this relationship moving forward. There are research that try to establish a direct relationship between contractor selection strategy and the outcome of the construction project. There are also decision support tools such as AHP or ANP that help clients prioritise various factors when selecting contractors. However the majority of these research and tools are informed by self-perception questionnaires and surveys that makes it difficult to gauge the strength of the relationship between contractor selection and project outcomes. In other words, there are hardly any empirical research that tries to establish this relationship. Literature review on the sources of cost overruns did not entirely reveal contractor selection as a main source of cost overrun; although from the explanations given for causes of cost overruns, one would be able to see how wrong contractor selection does play a part. Literature review on the various approaches to contractor selection on the other hand, did little to show the effect of contractor selection on the outcome of construction projects. Hence, the future direction of the research is to help clients see choosing a particular contractor selection strategy; whether lowest bid, or best value, affects the outcome of a construction project: cost and duration.

Keywords: cost overrun, contractor selection, best value, lowest bid.

1. INTRODUCTION

In today's competitive construction environment, it is almost impossible to achieve project success without adequate selection of the winning contractor. Wrong contractor selection can lead to disputes, lengthy dispute resolutions, project or contractor termination, low quality work and defects. Selecting the lowest bid has long been the traditional method of choosing contractors in construction. As recent as 2015, the National Construction Survey for the UK industry found this as the most used strategy for awarding contracts (NBS, 2015). However, Palaneeswaran and Kumaraswamy (2001) have argued that basing the final choice of contractor based solely on the lowest price, does not guarantee the delivery of the required outcome in terms of cost, time and quality. This is due to the fact that, they believe, that most clients ignore the fact that the same contractor performs differently in a dissimilar environment. Furthermore, Kashiwagi and Byfield (2002) say that though lowest price criterion is an objective and transparent approach, it fails to guarantee the quality of the contractor's performance. Thus, the lowest bid price may not correspond to the most economic choice in the long term; in other words may not result in a lower overall cost. This is due to the fact that selecting contractors based on the lowest bid price motivates contractors to provide minimally acceptable construction products (Kashiwagi and Byfield 2002).

This has led to the introduction of the best value strategy, which is to select contractors on the combination of price and quality. But what is quality? This is the client's discretion; the meaning of quality differs from client to client. Stilger et al. (2015) noted that there are over thirty-eight available formulas to calculate the best value contractor, all of which may provide a different winning contractor if used on the same project. Furthermore there are different methods that have also been developed to help select the best value contractor. Selecting on the lowest bid is objective and transparent, while selecting on best value is vague. Kashiwagi and Savicky (2003) say that owners are reluctant to pay more for best value if they do not understand what best value is. We are also seeing the use of selective tendering in the UK, particularly in the private sector, whereby clients have a list of preferred contractors; perhaps due to familiarity and trust, or because those contractors have passed a prequalification process, and from there select the lowest bid for any of their project. This is not a way of selecting on best value however, but how can one justify to the client to do otherwise? From the existing literature, there have been efforts to do so, though they may not be considered strong enough.

The idea is not to advocate for one strategy over another. Instead, it is to show clients the effects a contractor selection strategy; whether lowest bid or best value have on the outcomes of a project before they decide on the strategy to go for. Project outcomes can mean a number of things but the proposed study focuses on the outcome cost and duration due to its objectivity. There are existing studies that have tried to establish a link between contractor selection and project outcomes which will be critiqued in this paper. But first, it is important to understand the sources of cost overruns. By doing this, one will understand that although selecting a competent contractor influences project success, it is not the only antidote.

2. SOURCES OF OVERRUNS

In a construction project, whenever there is a budget increase, a cost increase, or cost growth, it means that the project has overran (Love et al., 2014). The reasons for cost overruns in construction projects are vast, however the ones that seem to come up the most stem from Flyvberg et al. (2008) and Cantarelli et al. (2010) studies.

Flyvberg et al. (2008) studied the cost performance of 258 transportation projects in 20 nations worth US$90 billion and found that ninety percent of them overran their cost. The study grouped the reasons for this cost overrun into three groups: technical, psychological, and political-economic; explaining the meaning of these groups. The Cantarelli et al. (2010) study then added to the latter study by offering examples of these groups. Below are tables that summarise the reasons for cost overruns from Flyvberg (2008) and Cantarelli et al. (2010).

Table 1: Causes of Overruns Group and Examples/Explanation

Group	Flyvberg (2008)	Cantarelli et al. (2010)
Technical	Inaccurate and unreliable data. Technical complications in project leading to increased costs.	Incomplete estimates, poor project design, scope changes, uncertainty, inappropriate organizational structure, inadequate decision-making process etc.

Psychological	Optimism bias; being overly-optimistic about the implementation of the project.	Optimism bias among local officials, cognitive bias of people, cautious attitudes toward risk.
Political-economic	Strategic misrepresentation; overestimate benefits and underestimate costs.	Deliberate cost underestimation, manipulation of forecasts, private information. Lack of incentives, lack of resources, inefficient use of resources, inadequate contract management etc.

Source: Flyvberg (2008) and Cantarelli et al. (2010). Adapted by researcher

The technical aspect of cost overruns can be attributed to risk and uncertainty; the failure of managing them adequately leads to cost overrun. It is important to understand that, despite the fact that the two are used simultaneously, risk and uncertainty are two different things. Ustinovicius et al., (2007) say that the reason the two are used simultaneously is because "uncertainty" is used in most scientific literature concerning risk management, while uncertainty management is concerned as managing perceived threats and opportunities; including their risk implications, as well as managing the various sources of uncertainty which give rise to and shape risk, threat and opportunity.

Flyvbjerg (2008) offers optimism bias as a psychological explanation for cost overruns; this theory is primarily from behavioural studies and it is to do with the inclination for people to be overly positive when making predictions about the outcomes of future planned actions (Siemiatycki, 2010). Nicholas (2004) suggests that estimators usually have to rely heavily on their own experience and historical information when preparing initial estimates. Which also explains why Flyvbjerg (2009) refers to optimism bias as delusion in the following way:

"Delusion accounts for the cost underestimation and benefit overestimation that occurs when people generate predictions using the inside view. Executives adopt an inside view of the problem by focusing tightly on the case at hand, by considering the plan and the obstacles to its completion, by constructing scenarios of future progress, and by extrapolating current trends. In other words, by using typical bottom-up decision-making techniques, they think about a problem by bringing to bear all they know about it, with special attention to its unique details. There are two cognitive delusions the inside view facilitates: the planning fallacy and a heuristic rule-of-thumb called anchoring and adjustment."

Strategic misrepresentation alludes to suspicion of foul play and corruption (Flyvbjerg, 2008; Flyvberg, 2009) a situation whereby forecasters and planners knowingly overestimate benefits and underestimate costs in order to win the project or get approval and funding; this refers to its political-economic explanations. Flyvberg (2009) refers to this as deception which is described in the following way:

"Deception accounts for flawed planning in decision making in terms of politics and agency issues. The political and organizational pressures in executive decision making involve: the principal agent problem and the sources of strategic deception."

Though cost is an important factor that gauges whether a projects was successful or not, it is not the only factor. The project duration is another important factor; and the causes of delay can also be seen in Cantarelli et al. (2010) and Flyvbjerg's (2008) study. From these studies we see that there are a number of reasons why a project is unsuccessful; contractor selection is one of the reasons but may not be the only reason why a project turns out bad. Nevertheless, this is enough reason to establish the link between contractor selection strategy and project outcomes: cost and duration. The next section reviews the various methods to picking a contractor on best value.

3. CONTRACTOR SELECTION METHODS FOR BEST VALUE

There are a plethora of tools developed to assist in clients in selecting the best contractors for executing a construction projects. This section will examine them.

Lo and Yan (2009) developed simulation models to analyse contractors' pricing behaviour and dynamic competition process under the qualification based system (QBS). The strength of this research is that it is possible to identify an unrealistic bid using the model. Furthermore El Asmar et al. (2009) used simulation to quantify criteria and combine them into a single score when assessing contractors. The major drawback to this research is the assumption that it could be used in all types of projects to assess contractors. Construction projects usually differ; clients' needs also differ and models should be able to take this into consideration. Having said that, there are methods that exist and were introduced a while ago that are being used as contractor selection approaches to account for the clients' needs or the specific needs of the project at hand. The AHP, being one, is a popular technique used for ranking and prioritising criteria used in selecting contractor; it is able to analyse multi-criteria problems according to pairwise comparison scale. According to Fong and Choi (2000) the technique identifies contractors with the best potential to deliver satisfactory outcomes in a final contractor selection process which is not based simply on the lowest bid. One of the main benefits of this tool is that it can be combined with other tools to assist decision makers such as fuzzy logic and ANP. The ANP in particular is an extension for the AHP to allow for interdependencies between criteria in selecting contractors (Cheng and Li, 2004). Abdelrahman et al. (2008) introduced a concept of best value modelling that was specific to each project. It combined the AHP and the weighted average method to quantify the qualitative effect of subjective factors in selecting the contractor. This particular study was relatively easy to understand and implement, however there is a high level of subjectivity to this study. The weights given to the criteria was the researchers discretion, even at that there is no real evidence that this criteria used to select the contractors will result in project success. Although it is fair to add, that the main purpose of their o study was to assist in selecting the best value contractor not whether the best value contractor will be successful or not. Similar studies have also been undertaken like Kwong et al. (2002) and Bevilacqua and Petroni (2002), which used the combination of a scoring system and fuzzy theory for ranking the best value bids. Bendana et al. (2008) also developed a fuzzy logic assessment model both the qualitative and quantitative issues that influence whether or not a contractor is suitable to win the bid for the project. Zadeh (1965) first introduced the concept of fuzzy set, which basically transforms linguistic variables that are ill-defined into traditional quantitative terms (El Agroudy et al. 2009). In this type of study contractors are scored in each criteria as Low, Medium, and High (1, 2, and 3). Then depending on the number of criteria used to assess the contractors, let us say for example 5, this usually results in a final score for each contractor between 5 and 15. So if a contractors' score is between 5 and 9 they will be considered Poor. 10 and 13 will be considered good, while 14-15 is Very Good. This is just an example of a scale used, each client can subsequently their own scale. However using this example, one can question how sensitive the scores are to subjectivity; with the fact that at 9 a contractor is considered Poor and at 10 Good. Assuming the choice of the contractor boiled down to 9 and 10 contractors, with the latter at a higher price. How can it possibly be justified to the client to select the contractor with the score 10 at a higher price, when it's supposed 'quality score' is just one above a contractor with a lower price? How much of a difference does that one point make in the project outcome? The strength of this technique however is that it can be tailored to the owners' requirement; the client should have the power to score contractors the way the like, but whether that results in project success usually remains unclear until the end of the project.

Other research have proposed the use of multi-criteria evaluation model for contractor selection; Topcu (2004) for one incorporated this method for construction contractor selection in the Turkish public sector. A major strength of these models is the capacity to allow more factors that are likely to influence a contractor's performance to be taken into consideration. Zavadskas et al. (2008) demonstrated this in its research by developing a contractors' assessment and selection based on the multi-attribute method. There are also models that have been developed to assess the contractors after project completion. Hancher and Lambert (2002) developed an evaluation system to evaluate the performance of contractors at the end of each year of project duration. Minchin and Smith (2005) also produced a quality based performance rating system model that generated an index for each contractor to represent contractor's quality over a specified frame. Despite the vague nature of quality really is, these research at least tries to establish a link between contractor selection and the outcome of the project by assessing the contractors. By doing so, clients can take these assessments into consideration for future projects.

It is also worth mentioning that the use of subcontractors in the construction industry has been steadily on the rise. Main contractors are now subcontracting majority of the works of a project which means that subcontractors should be assessed as well. Albino and Garavelli (1998) have proposed a neural network process for subcontracting rating. While, Arslan et al. (2008) developed a web based subcontractor evaluation system called WEBSES for the Singaporean construction industry that evaluated contractors based on combined criterion. Interserve Plc, also run a database that scores subcontractors performance on past projects for main contractors. With the increase in selective tendering; whereby a client has a preferred list of contractors, it makes it difficult for small to mid-size companies or companies in general who are not in the list to win work. Hence, these companies result to being subcontractors.

There are a plethora of research that are aimed to determine the best value contractor, whether they are mathematical models, or linear weighting models, or statistical approach; all of which include cluster analysis, simple weighting, AHP, fuzzy set theory, discriminant analysis, etc. (Waara and Bröchner 2006; Tsai et al., 2007; Lambropoulos 2007). However, these methods do little to show the effect of a contractor selection strategy: either lowest bid or best value, has on the outcome of a construction project: final cost and duration. El-Abassy et al. (2013, pp 766) recommends a further study:

"if the developed model determined the best contractor for a project whose submitted price is not the lowest price, then an analysis should be done to show what-if scenarios for the contractor with the lowest price if he/she is awarded the contract instead. The analysis can

include the response to claims for this contractor, the rework that may occur during the project because of inadequate past experience, for example, or any other weak points for the contractor with the lowest price that may result in an extra cost beyond the original price. These extra costs might include (1) rework because of bad quality, (2) delays because of incompetence, (3) short life cycle because of bad quality material, (4) operation and maintenance problems because of inadequate experience, and (5) many claims because of bad management."

The research will aim to carry out this further study, but not by assuming that the lowest tenderer has all these problems. Rather by using historic data and analysing how they have performed in the past, to predict how they will likely perform in the future. Yu and Wang (2012) say that the market should dictate what strategy to go for; meaning that there are times when it is best to for the lowest bid strategy. The next chapters will now aim to provide a conceptual model that seeks to provide a quantifiable methods of assessing the risks of choosing the different basis for contractor selection for specific projects. Up to date there has been no quantitative assessment of the frequency distribution of the final outcome cost and duration of either selection method. The client may want to know not just the expected outcome cost of a particular strategy but also what would be the probability of a strategy leading to an extremely high final cost. In other words, is there a chance that one selection criteria would give the lowest cost on average but could, on occasions, give to outcome costs so high that bankruptcy may occur?

Therefore we see that there are many approaches and models that have been developed for contractor selection; some with a view of showing how they affect outcomes. However, the bulk of this studies have done little to justify to a client why he/she should pay more for a best value contractor over the lowest bid contractor. The lowest bid contractor can turn out to be the best value contractor after they have been ranked. But when the lowest bid contractor is not the best value contractor, how can it be justified to the client to go with the best value contractor especially when working under tight margins. A method should be developed that shows that if a contractor is picked whose price is not the lowest price, how will the lowest priced contractor fare if he/she is given the contract instead. The method proposed in the next section should be viewed as an extension to these various approaches of selecting the best value contractor not the replacement. Also establishing a link between contractor selection and project outcomes from the perspective of a main contractor picking a subcontractor is necessary, but a link between selecting the main contractor and the overall project outcome is more important. A main contractor, if it chooses to can subsequently subcontract all the works on a project, and not just to one subcontractor but a multiple of them. Therefore selecting the right strategy to go for is important. But due diligence must start from the beginning of selecting the main contractor. A main contractor picked on the basis of lowest bid will subsequently subcontract to the lowest bid, and this is the case with the best value contractor. The proposed method should not try to dissuade a client from going for the lowest bidder, instead to show the client the range of possible outcomes available if it does go with either the lowest bid or the best value bid.

4. PROPOSED METHOD

The proposed method is not seeking to select the best value contractor. The proposed method is one that seeks to use Monte Carlo simulation to produce frequency distributions of all the possible outcomes in terms of cost and duration when a client decides on a strategy: lowest bid or best value. This method can be taken solely as a cost estimation technique, however the difference here is that the method does not just set out to purely estimate the cost or the duration of a project. Instead, it will incorporate the strategy; whether lowest bid or best value, by which the contractor was selected. Furthermore, it does not set out to predict the final cost or duration of the project, rather the range of outcomes that can be expected for a project depending on the strategy chosen. By doing so a direct link can be established on how contractor selection affects the outcome of a construction, if it does at all.

For this to happen historical data on projects will have to be analysed. The details and requirements needed to develop this model include:

- Details of the contract awarded (tender bids received from all the contractors that bided for the project; companies were anonymous)
- Selection criteria; (lowest tender accepted)
- The wining contractor: the eventual tender accepted
- Project outcome cost: initial tender cost, final cost, the expected duration, and actual duration.
- Same sector projects (e.g. educational facilities, hospitals etc.)

The study here is to whether awarding to lowest tender will result in a higher cost and project time than awarding to the best value tender. There is a pre-conceived notion that the best value tender whose price is not the lowest price will generally fare better in a project than the lowest bid tender. Hence, analysing historic data on similar types of project that selected the lowest tender, can give us a general view of how they might fare in a project that selected the best value tender.

From the details provided correlations can be derived from variables that will be inputted into the model:

- Bid price (BP, which in this case, is always the lowest tender)
- The difference between the final cost of the project and the tender bid (Diff)
- Delay
-

The correlation between these variables are then used to derive numbers that are inputted into the model. Which is then able to generate frequency distribution of the tender bids accepted (which will be instructed to always be the lowest tender), a Diff cost, and Delay time. Subsequent analysis will then be undertaken by the model to calculate the frequency distributions of the total cost and actual duration of the project. Therefore the idea here is that when a client is assessing tender bids, and it knows it best value tender, this model will be able to show how the lowest tender will fare.

Monte Carlo simulation technique is not new, this has been applied in various fields including construction. Below are a few examples:

Wall (1996) collected 216 office building from the BCIS database of RICS to outline the issues that should be recognised when using Monte Carlo methods. The study concluded that lognormal distributions are superior to beta distributions in representing a data set. Furthermore the result of this study show that the effect of excluding correlations is more profound than the effect of choosing between lognormal and beta distribution to represent a data set.

Clark (2001) details another example of a Monte Carlo application provided by the Honeywell Performance Polymers and Chemical, which used the tool to estimate contingency on 47 projects ranging from US$1.4 million to US$505 million.

Moghaddam (2015) combined hybrid Monte Carlo simulation and goal programming to develop a method for supplier selection and order allocation in closed loop supply chain systems.

Vose (2000) highlights some of the main advantages to Monte Carlo:

- It does not require specialist knowledge in mathematics.
- Computer applications are commercially available and can be used to run the analysis.
- Monte Carlo simulation is a parallel process; i.e. iteration results are independent of each other.
- The model elements can be correlated for more reliable and realistic scenarios.

Furthermore there are tools available to carry out this technique. The @RISK software is a popular tool that is used for this analysis by both academics and practitioners. GoldSim is also another popular tool. There is also MATLAB, and Mathematica; therefore there are a number of software packages that can be utilised for this study.

The major challenge to this study is seeing whether client companies are willing to release such sensitive information, not only does this study need their consent, but the consent of the contractors involved in the project. The benefit to this study however, is the fact that results can be presented in different forms; most importantly in terms of financial numbers. Having said that, if companies are unwilling to release such sensitive information, there are databases that have the details and requirements needed to carry out this research. One being the Building Cost Information Service (BCIS) database from the Royal Institution of Chartered Surveyors (RICS hereafter). The downside to it may possibly only harbour projects that did well or not too badly, therefore result would be interpreted with a bit of caution. Nevertheless, it will be able to offer a practical example of the benefits of this study.

5. CONCLUSIONS

The approaches to contractor selection were analysed; there are essentially two strategies to selecting a contractor: lowest bid, or best value tender. The lowest bid is relatively straightforward and simple, the best value tender is not. The literature is rich with approaches and models for selecting the best value contractor; from simple weighting, to AHP, ANP, fuzzy theory etc. The literature is rife with models developed to select the best value bid. The proposed method is not one of them; the proposed method here should be seen as an extension. So if a best value tender is selected whose price is not the lowest price, there should be a method to justify to the client that the lowest tender would not fare better. The study is not advocating for one strategy over another nor is it a tool for selecting the best value contractor. Instead, it will show all the possible outcomes involved when a client decides on a strategy: lowest bid or best value. There are cases when it will make economic sense to go for the lowest bid strategy, while there are other cases where it is best to go for the best value bid. This proposed method of analysing historic data on how these strategies have fared in past projects, in order to develop a model that will produce frequency distributions of outcomes of a strategy will help clients decide on what strategy to go for. The next step of the PhD research is to analyse sector specific projects, all of which have selected the lowest bid. This would be used to develop a model that will be able to predict the likely range of outcomes: final cost and duration of the lowest tenderer in future projects in that sector. Furthermore if a client's selection criteria is best value and it turns out that the best value contractor does not have the lowest bid, this model would then be able to show how the lowest bid amongst the tenders would have fared if he/she was given the contract instead.

6. REFRENCES

Abdelrahman, M., Zayed, T., and Elyamany, A. (2008). Best-value model based on project specific characteristics. Journal of Construction Engineering Management, 134 (3), 179–188.

Albino, V., and Garavelli, A. C. (1998). A neural network application to subcontractor rating in construction firms. International Journal of Project Management, 16(1), 9–14.

Arslan, G., Kivrak, S., Birgonul, M. T., and Dikmen, I. (2008). Improving sub-contractor selection process in construction projects: Web-based sub-contractor evaluation system (WEBSES). Automation Construction, 17(4), 480–488.

Bendana, R., Cano, A., and Pilar de la Cruz. (2008). Contractor selection: Fuzzy-control approach. Canadian Journal of Civil Engineering, 35(5), 473-486.

Bevilacqua, M. and Petroni, A. (2002). From traditional purchasing to supplier management: a fuzzy logic-based approach to supplier selection. International Journal of Logistics, 5(3), 235-255.

Cantarelli, C. C., Flyvbjerg, B., Molin, E.J.E., and van Wee, B. (2010). Cost Overruns in Large-Scale Transportation Infrastructure Projects: Explanations and Their Theoretical Embeddedness, European Journal of Transport and Infrastructure Research, 10(1), 5-18.

Cheng, E.W. and Li, H. (2004). Contractor selection using the analytic network process. Construction Management and Economics, 22(10), 1021-1032.

Clark, D.E. (2001). Monte Carlo analysis: ten years of experience. Cost Engineering, 43(6), 40-45.

El Agroudy. M., Elbeltagi, E., El Razek A, M, E. (2009). A Fuzzy Logic Approach for Contractor Selection. In: Fifth International Conference on Construction in the 21st Century (CITC-V) "Collaboration and Integration in Engineering, Management and Technology" May 20-22, 2009, Istanbul, Turkey.

El Asmar, M., Hanna, A., and Chang, C. (2009). Monte Carlo Simulation Approach to Support Alliance Team Selection. Journal of Construction Engineering and Management, 135(10), 1087-1095.

El-Abbasy, S.M., Zayed, T. M.ASCE., Ahmed, M., Alzraiee, H., and Abouhamad, M. (2013). Contractor Selection Model for Highway Projects Using Integrated Simulation and Analytic Network Process. *Journal of Construction Engineering and Management*, 139(7), 755-767.

Flyvbjerg, B (2008) Curbing optimism bias and strategic misrepresentation in planning: Reference class forecasting in practice. European Planning Studies, 16(1), 3-21.

Flyvbjerg, B. (2009). Survival of the unfittest: why the worst infrastructure gets built—and what we can do about it. Oxford Review of Economic Policy, 25(3), 344-67.

Flyvbjerg, B., M.K. Skamris Holm and S.L. Buhl. (2002). Underestimating cost in public works. Error or Lie? Journal of the American Planning Association, 68(3), 279-295.

Fong, P. S., and Choi, S. K. (2000). Final contractor selection using the analytical hierarchy process. Construction Management Economics, 18(5), 547–557.

Hancher, D. E., and Lambert, S. E. (2002). Quality based prequalification of contractors. Journal of Transportation Research Board, 1813(0361–1981), 260–274.

Kashiwagi, D. and Savicky, J. (2003). The cost of 'best value' construction. Journal of Facilities Management, 2 (3), 285-295.

Kashiwagi, D., and Byfield, R. E. (2002). Selecting the best contractor to get performance: On time, on budget, meeting quality expectations. Journal of Facilities Management, 1(2), 103-116.

Kwong, C.K., Ip, W.H., and Chan, J.W.K. (2002). Combining Scoring Method and Fuzzy Expert Systems Approach to Supplier Assessment: A Case study. Integrated Manufacturing Systems, 13(7), 512-519.

Lambropoulos, S. (2007). The use of time and cost utility for construction contract award under European Union Legislation. *Building and Environment*, 42 (1), 452–463.

Lo, W. and Yan, M. (2009). Evaluating qualification-based selection system: A simulation approach. Journal of Construction Engineering and Management, 135(6), 458-465.

Love, P E D, Smith, J, Simpson, I, Regan, M, Sutrisna, M and Olatunji, O. (2014). Understanding the Landscape of Overruns in Transport Infrastructure Projects. Environment and Planning B: Planning and Design, 42(3), 490-509.
Minchin, R. E., Jr., and Smith, G. R. (2005). Quality-based contractor rating model for qualification and bidding purposes. Journal of Management and Engineering, 21(1), 38–43.
Moghaddam, K.S. (2015) Supplier selection and order allocation in closed-loop supply chain systems using hybrid Monte Carlo simulation and goal programming. International Journal of Production Research, 53(20), 6320-6338.
NBS (2015). The National Construction Contracts and Law Survey 2015. [online] Available from: https://www.thenbs.com/knowledge/nbs-national-construction-contracts-and-law-survey-2015-finds-disputes-continue-to-blight-construction-industry [Accessed: 21st February 2017].
Nicholas, J.M. (2004). Project Management for Business and Engineering: Principles and Practice. 2nd ed. MA, USA; Oxford, UK: Elsevier Butterworth-Heinemann
Palaneeswaran, E., & Kumaraswamy, M. (2001). Recent advances and proposed improvements in contractor prequalification methodologies. Building and Environment, 36(1), 73-87.
Siemiatycki, M. (2010). Managing Optimism Biases in the Delivery of Large-Infrastructure Projects: A Corporate Performance Benchmarking Approach. European Journal of Transport and Infrastructural Research, 10(1), 30-41.
Stilger, S.P., Siderius, J. and van Raaji, E.M. (2015). A Comparative Study of Formulas for Choosing the Economically Most Advantageous Tender. [online] Available from: http://poseidon01.ssrn.com/delivery.php?ID=441004005103024112072110086065081113032072036040057060073084089069004068103027008111059039125012027123008108115091120112021123117037021023046027089014101082120026070071038078086081118126091015064110122026000121004000097107071119092065112101096098092085&EXT=pdf [Accessed: 21st February 2017].
Topcu, Y. (2004). A decision model proposal for construction contractor selection in Turkey. Building Environment, 39(4), 469–481.
Tsai, H., Wang, L., and Lin, L. A. (2007). Study on improving the ranking procedure for determining the most advantageous tender. *Construction Management Economics*, 25 (5), 545–554.
Ustinovicius, L., Migilinskas, D., Tamosaitiene, J., Zavadskas, E.K. (2007). Uncertainty Analysis in Construction Projects Appraisal Phase. [online] Available from: http://leidykla.vgtu.lt/conferences/MBM_2007/2pdf/Ustinovicius_Migilinskas.pdf [Accessed: 21st February 2017].
Waara, F., and Bröchner, J. (2006). Price and non-price criteria for contractor selection. *Journal Construction Engineering Management*, 132 (8), 797–804.
Wall, M.D (1996). Distributions and correlations in Monte Carlo simulation. Construction Management and Economics, 15, 241-258.
Yu, Wen-der and Wang, Kwo-Wuu (2012). Best Value or Lowest Bid? A Quantitative Perspective. *Journal of Construction Engineering and Management*, 138, 128-134.
Zadeh, L.A. (1965). Fuzzy Sets. Information and Control, 118, 338-353.
Zavadskas, E., Kazimieras, T. Z., and Tamosaitieme, J. (2008). Contractor selection of construction in a competitive environment. Journal of Business Economics and Management, 9(3), 181–187.